How does prolonged drought affect plant physiological processes? - Focus on the interactions with increased temperature and elevated [CO2] within the CLIMAITE project?

Albert, Kristian; Ro-Poulsen, Helge; N. Mikkelsen, Teis

Publication date:
2006

Document version
Publisher's PDF, also known as Version of record

How does prolonged drought affect plant physiological processes? - Focus on the interactions with increased temperature and elevated [CO_2] within the CLIMAITE project?

By Kristian Albert, Helge Ro-Poulsen and Teis N.Mikkelsen

Within the CLIMAITE project following manipulations are made according to a realistic Danish climatic scenario anno 2075: 1) ElevatedCO_2 to 510 ppm by means of FACE technology 2) Passive night time warming by approximately 2^0C air temp by means of heat reflective curtains 3) Extended summer drought from about June until end of July until soil water content are close to 4-5% by means of automatized curtains. The investigated plant species are the grass *Deschampsia flexuosa* and the evergreen heather *Calluna vulgaris* in a semi-natural heathland on sandy soil. The site has both a low water holding capacity and nutrient limitation is indicated of Phosphorus to a higher degree than Nitrogen. Focus is on plant photosynthetic performance and initially a large effort is primarily to detect effect of treatments and secondly investigate their mechanisms. This is being done by conducting measurements on the leaf scale throughout field season by 1) traditional CO_2 and H_2O gas-exchange 2) Plant stress detection by PAM fluoriometry and Chlorophyll-a fluorescence induction curves 3) Leaf content of Chlorophyll-a, C, N 4) Carbon isotopes 5) Water potential. The allocated techniques and protocols aims at answering the following intriguing questions: What are the potentially plant responses? And what do the actually do? - Close collaboration with other Ph.d projects aims at linking the plant performance to plant biomass build-up both above and bellow ground, net ecosystem gas exchange by chamber measurements and spectral analysis of canopy reflectance. At bottom line the plant photosynthetic studies goes in as input to the ecosystem responses. More about the plant responses: In general, the application of pulse-induced treatments, the short-term effects (5 years) will be different from the longer-term effects (>5 years) due to differences in response-time in different ecosystem components and processes. Initially, the pre-treatment function will change strongly and in a directed manner, but the rate of change will decrease over time as the system approaches a new “dynamic equilibrium”. The seasonal variation in climate fx. temperature and precipitation patterns will lead to large yearly and seasonal differences. Balancing the responses to the drivers also very much depends on whether the plants are mostly water limited vs nutrient limited. Specifically the plant response to Increased CO_2 will lead to higher carbon sequestering and better water use efficiency and will be negatively affected by a prolonged summer drought and night time warming. Although the mechanisms may differ as 1) Drought may affect stomata conductance, increase the plant stress (direct and indirect effects on PSII), respiration processes, leaf content of carbon isotopes and water potential whereas 2) Night time warming may to affect respiration processes primarily and accelerate drying of soil adding ‘drought effects’. Net result of manipulation combinations on photosynthesis will depend on the realised plant response capacity. We argue that plant responses are mediated by the strength of each manipulated driver which in nature differs through season. This may lead to different impact through season and ads to complexity, in particular when separation of the underlying mechanisms is to be made.